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# AN APPLICATION OF NUMBERWORK IN NATURE-STUDY

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A paper twice as long as this could easily be written as a polemic against the too prevalent practice of teaching arithmetic *in se* and without proper reference to the other subjects of the curriculum. It is not my purpose, however, to enter into an extended argument against the formal methods of teaching numberwork, such methods have already received stronger condemnation than I am able to give them.[1] I shall assume, therefore, as evident that a purely formal subject like arithmetic should be closely integrated — incarnated as it were — with subjects of more intrinsic worth. It is in the development and the clarification of these subjects that numberwork finds its real value. Wherever there is a quantitative relationship to be determined, and whenever the pupil finds it necessary to his progress to make this determination, then the use of numberwork finds its justification.

Numberwork cannot be successfully *injected into* the material, but it must arise out of the conscious need of a solution of the problem. Indeed, this seems to be a truism in actual business affairs. The banker and the broker use percentage, discount, commission, etc., because these arithmetical relationships are felt necessities in the furtherance of their work. Their interest is primarily in a familiar content and only incidentally in the form which embodies this content. To them, then, the solution of the problem in percentage is interesting, because worth while.

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[1] For an able and critical review of the formal presentation of numberwork in the elementary school, I would refer the reader to an article by W. S. Jackman, the editor of this magazine, appearing in *Educational Review*, 1903, Vol. V, p. 35.

Yet it is just here that the presentation of arithmetic in the ordinary school breaks down. Bank discount, brokerage, stock exchange, etc., *in se,* are not interesting to the young pupil, since their content is totally unfamiliar. The pupil, moreover, has no real purpose in the solution of the problem; consequently the interest — if there be any — is that belonging to mental gymnastics. The makers of arithmetics have copied the forms of business life, but have missed the spirit. At the risk of repetition, I urge that numberwork must be evolved out of a content in which the pupil is vitally interested. Ordinary problems, such as, "If a hound can take two leaps to the hare, then," etc., are species of mental folderol.

Aside from the lack of real interest and loss of time involved in the formal presentation of numberwork, another serious evil is to be noted: Arithmetic taught as a discrete subject tends to remain discrete. Unconnected and uncorrelated with the larger and richer subjects of the curriculum and of the daily life of the pupil, its use does not become habitual, since its accustomed content is not that of daily experience. Hence, the average person drops the use of mathematics just as soon as school days are over.

On the other hand, however, the incorporation of numberwork in an experienced content insures for it all the interest, and all the stability and permanence that belongs to the content itself. The interest, moreover, originally felt in the subject-matter is strengthened, since new relations are brought out and fresh determinations are made. The result is increased accuracy and clearness of conception — which is the essence of science.

I have stated the above principles very succinctly, yet I trust sufficiently clearly for the purpose of putting forth the ideas that have been the controlling motives in the presentation of numberwork as an organic part of a series of lessons given in the fifth grade of the Elementary School of the University of Chicago. The central topic of the series was "The Cereals of North America." It is not essential to state here the outline used in the development of the subject-matter; let it suffice to remark that maps, pictures, drawings, reading lessons, actual planting of seeds, etc., were freely used as the work progressed. The problems given below arose out of a visit to a flour mill. They are in no sense manufactured, but are rather questions arising out of the relationships existing in the material. Consequently they may lack the order and the logical symmetry belonging to a prearranged set of problems found in the arithmetic, yet they possessed for the pupils a real quickening interest as instruments in the successive unfolding of the main topic of study—an interest accompanying clear and purposive conception.

An entire morning was given over to an excursion by the class of about thirty pupils to the flour mill of Eckhart & Swan, 377 Carroll Avenue. Through the courtesy of the officials of the mill the pupils, under the able guidance of Head Miller Rachel, were enabled to see the entire process of transformation of the wheat into flour. Beginning with the unloading of the cars on the side track, the storing and weighing of the grain in the elevators, the observation was carried out through each move until the final product was reached. During this observation work the pupils and teachers asked certain questions that were the data for subsequent quantitative determinations. Every problem, therefore, is based on the actual conditions found in the business of Eckhart & Swan.

1. If a car holds 1,000 bushels of wheat, how many pounds will it hold?
2. How many carloads will it take to fill Eckhart & Swan's elevator, holding 800,000 bushels of wheat?
3. How long a train will these cars make, if each car is 36 feet long? Answer in feet, yards, and miles.
4. How long a time will it take to fill the elevator, working eight hours a day, if a car can be unloaded in 20 minutes? Answer in days, hours, minutes.
5. What is the value of the wheat in Eckhart & Swan's elevator, when wheat is worth — (market price) per bushel?
6. If the daily capacity of Eckhart & Swan's mill is 2,500 barrels of flour, what is its annual capacity, based on 300 working days?
7. If it takes 4⅔ bushels of wheat to make one barrel of flour, how many pounds does it take to make a barrel of flour?
8. A barrel of flour weighs 196 pounds; how much of the wheat goes into bran, middlings, and "waste"?
9. One twenty-first of the by-product (bran, middling, etc.) is "waste," how many pounds is this to each barrel?
10. How many pounds are wasted each day? How many bushels? How much is wasted for the year of 300 days? Answer in pounds and bushels.

11. How much bran and middlings in pounds are made each day? During the year?

12. Bran and middlings are worth 85 cents per hundred pounds; what is the value of the output of Eckhart & Swan's mill for one day? For one year?

13. Flour is worth $6.25 per barrel; what is the value of the daily output of Eckhart & Swan's mill? What is the value of the yearly output?

14. What is the value of the output of flour, bran, and middlings for the year?

15. If wheat is worth — (market price) per bushel, how much is it worth per pound? How much is flour worth a pound? How much is bread worth a pound? How much more is bread worth a pound than flour? Than wheat?

16. If one acre of ground will raise 18 bushels of wheat (based on Government Report on Indiana, where most of wheat used in Eckhart & Swan's mill came from), how many acres will it take to raise enough wheat to fill the elevator of Eckhart & Swan? How many acres will it take to raise the wheat for the yearly output of the mill?

It was not expected that each pupil should work every example in the above set; yet every pupil worked some of them and was interested in all. An information was gained by the use of these problems that could not be obtained in any other way.

Underlying, and in a sense supporting and increasing, the interest arising out of the development of knowledge concerning the flour mill, was another interest of even more significance and depth — an interest inherent in social service. That is, the pupils looked forward to, and were inspired by, the idea that they were to tell the rest of the school this information that they had worked out. For it is customary in the University Elementary School for reports to be made from time to time by the various classes on certain phases of their work at the period of the morning exercise before the entire school. For instance, one class may present a drama that they themselves have created, as was done by the members of a French class; at another time a report may be made of a visit to an art gallery. So a morning exercise was set aside for this class to present to the school their visit to the flour mill.

It is outside my purpose to note the features in detail that the pupils worked up and presented at this exercise. Briefly, each pupil of the class had a part in the exercise, and felt that he or she was an active participant in the social life of the school — nay more, was an indispensable agent in its social progress.

The mathematical relations, however, that were brought out in connection with this exercise were as follows:

It takes 800 carloads of wheat to fill the elevator once, and it requires thirty-three days, two hours, and forty minutes to do the work. The elevator requires 4⅜ fillings to run the mill for one year, or a total of 3,500,000 bushels of wheat. It would require a train of over 28,000 feet to fill the elevator once; a train of over twenty-three miles to supply the elevator for one year. The acreage used to supply this one mill alone for a year is 194,444 +, or over 300 square miles.

Again:

The yearly output of flour in barrels is 750,000, worth $4,687,500. The yearly output of bran and middlings is 60,000,000 pounds, worth $510,000; while the "waste" amounts to 3,000,000 pounds a year, or over 50 carloads. A comparison of value of a pound of bread was made with value of a pound of flour, and with value of a pound of wheat. [This will be taken up in detail after the pupils visit a bakery.]

The above quantitative relationships were concerned with one mill alone; the emphasis was upon that mill and its capacity and output. This left the pupils with a strong impression of its vastness, and of the reasources required to run it. Naturally this led to a comparison with the still greater capacity of the mills of Minneapolis and the matchless resources of the wheat belt ministering to them. It is not necessary to suggest that the study of this mill as a type-form opened the way for incursions into related fields of even richer content.